

1. A magnetostatically coupled multi-segmented magnetic tunnel junction (MTJ) cell, said cell having artificial nucleation sites for magnetization switching and a reduced sensitivity to defects and shape irregularities comprising:

at least two discrete, separated MTJ cell segments, the centers of said segments being distributed along a common line and forming, thereby, a linear chain of cell segments; and

the segments having a crystalline anisotropy; and

the segments having certain geometrical shapes; and

the segments being magnetized along said common linear direction; and

the magnetization of said segments being maintained by magnetostatic coupling between said segments; and

the magnetization of said segments being capable of a substantially simultaneous change in direction by the application of an external switching field to a location among said segments which provides a nucleation site for said direction change.

2. The multi-segmented MTJ cell element of claim 1 wherein each segment further comprises:

a ferromagnetic free layer;

an insulating tunneling layer formed on said free layer;

a multi-layered magnetically pinned layer formed on said tunneling layer, said pinned layer further comprising:

- a first ferromagnetic layer adjacent to said tunneling layer;
- a non-magnetic coupling layer formed on said first ferromagnetic layer;
- a second ferromagnetic layer formed on said coupling layer;
- an antiferromagnetic pinning layer formed on said second ferromagnetic layer; and

said multi-layered magnetically pinned layer has a net magnetic moment which is substantially zero as a result of the magnetic moments of said first and second ferromagnetic layers being substantially equal and strongly magnetically coupled in an anti-parallel configuration.

3. The segment of claim 2 wherein said free magnetic layer is a multilayer comprising a third and fourth ferromagnetic layer separated by a non magnetic spacer layer and wherein the magnetizations of said ferromagnetic layers are substantially equal and may be weakly or strongly coupled in antiparallel directions to produce a substantially zero net magnetic moment.

4. The segment of claim 2 or 3 wherein the tunneling layer is a layer of insulating material chosen from the group of insulating materials consisting of as  $\text{Al}_2\text{O}_3$ ,  $\text{ZrO}_2$  or  $\text{HfO}_2$  and combinations thereof.

5. The segment of claim 4 wherein the tunneling layer is a layer of  $\text{Al}_2\text{O}_3$  formed to a thickness of between approximately 5 and 50 angstroms.
6. The segment of claim 2 or 3 wherein the coupling layer is a layer chosen from the group of non-magnetic coupling materials consisting of Rh, Ru, Cr and Cu.
7. The segment of claim 6 wherein the coupling layer is a layer of Ru formed to a thickness of between approximately 5 and 50 angstroms.
8. The segment of claim 2 or 3 wherein the antiferromagnetic pinning layer is a layer chosen from the group of antiferromagnetic materials consisting of PtMn, NiMn, OsMn, IrMn, NiO, FeMn and CoNiO.
9. The segment of claim 8 wherein said pinning layer is a layer of PtMn formed to a thickness between approximately 30 and 300 angstroms.
10. The segment of claim 2 wherein the ferromagnetic free layer and the first and second ferromagnetic layers of the pinned layer are formed of ferromagnetic materials chosen from the group of ferromagnetic materials consisting of CoFe, NiFe, CoNiFe, CoZrTa, CoFeB and CoHfTa and are formed to a thickness between approximately 20 and 200 angstroms.

11. The segment of claim 3 wherein said first, second, third and fourth ferromagnetic layers of the pinned layer are formed of ferromagnetic materials chosen from the group of ferromagnetic materials consisting of CoFe, NiFe, CoNiFe, CoZrTa, CoFeB, CoZrTa, CoNbTa and CoHfTa and are formed to a thickness between approximately 20 and 200 angstroms.
12. The multi-segmented MTJ cell of claim 1, 2 or 3 wherein each segment of said cell is shaped by a process comprising photolithography and ion-milling.
13. The multi-segmented MTJ cell of claim 1, 2 or 3 wherein the shape of each segment of said cell is chosen from the group of segment shapes consisting of segments which are all circles of equal area, segments which are all circles of unequal area, segments which are all ellipses of equal aspect ratio, segments which are all ellipses of aspect ratio between 1 and 10, segments which are all ellipses of equal aspect ratio and equal area, segments which are all ellipses, segments which are all lozenge shaped and segments which are all complex geometrical shapes.
14. The multi-segmented MTJ cell of claim 13 wherein the centers of each cell segment lie on a common line.
15. The multi-segmented MTJ cell of claim 14 wherein each segment is circular.

16. The multi-segmented MTJ cell of claim 15 wherein each circular segment has the same radius.

17. The multi-segmented MTJ cell of claim 16 wherein there are two circular segments.

18. The multi-segmented MTJ cell of claim 14 wherein the cell forms a chain of between 2 and 10 circular segments.

19. The multi-segmented MTJ cell of claim 14 wherein the crystalline anisotropy of each segment is perpendicular to said common line.

20. The multi-segmented MTJ cell of claim 14 wherein each segment is elliptical and has a major axis perpendicular to the common line joining their centers.

21. The multi-segmented MTJ cell of claim 14 wherein each segment is elliptical with its minor axis being perpendicular to the common line joining their centers.

22. The multi-segmented cell of claim 21 wherein the cell forms a chain of between 2 and 10 elliptical elements and has a crystalline anisotropy that is perpendicular to the common line joining its centers.

23. The multi-segmented MTJ cell of claim 14 wherein each segment is lozenge shaped.
24. The multi-segmented MTJ cell of claim 22 wherein the cell forms a chain of between 2 and 10 lozenge shaped elements.
25. The multi-segmented MTJ cell of claim 24 wherein the crystalline anisotropy of each segment is perpendicular to the line joining its centers.
26. A method for fabricating a magnetostatically coupled multi-segmented magnetic tunnel junction (MTJ) cell, said cell having artificial nucleation sites for magnetization switching and a reduced sensitivity to defects and shape irregularities comprising:
- forming an MTJ layered stack, the magnetic layers of said stack having a common crystalline anisotropy;
  - patterning within said stack, by photolithography and ion-milling methods, at least two discrete, separated MTJ cell segments of certain geometrical shape, the centers of said segments being distributed along a common line and forming, thereby, a linear chain of cell segments; and
  - magnetizing said segments along the direction of said common line, whereby the magnetization of said segments is maintained by magnetostatic coupling between said segments.

27. The method of claim 26 wherein the method of forming the MTJ stack further comprises:

forming a ferromagnetic free layer;

forming an insulating tunneling layer on said free layer;

forming a multi-layered magnetically pinned layer on said tunneling layer, said pinned layer formation further comprising:

forming a first ferromagnetic layer adjacent to said tunneling layer;

forming a non-magnetic coupling layer on said first ferromagnetic layer;

forming a second ferromagnetic layer on said coupling layer;

forming an antiferromagnetic pinning layer on said second ferromagnetic layer,

wherein said multi-layered magnetically pinned layer has a net magnetic moment which is substantially zero as a result of the magnetic moments of said first and second ferromagnetic layers being substantially equal and strongly magnetically coupled in an anti-parallel configuration.

28. The method of claim 27 wherein said free magnetic layer is formed as a multilayer comprising a third and fourth ferromagnetic layer separated by a non magnetic spacer layer and wherein the magnetizations of said ferromagnetic layers are substantially equal and may be weakly or strongly coupled in antiparallel directions.